Solid Earth deformation and gravity changes due to surface loading: The new IERS/GGFC Special Bureau for Loading (SBL)

Presented by

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for

The SBL Team

- **Introduction**
  - **The Way to the SBL**
  - **Objectives**
  - **Membership**
- **Scientific Agenda**
- **Work, Tasks and Products of the SBL**
- **Outlook**

Objectives

Call for Proposals October 31, 2001:

Objectives

... IERS conventions currently do not give comprehensive recommendations for treating the loading signals due to the full range of possible effects. ...

... timely to set up the tools that provide a basis for a future conventional treatment of loading effects in all IERS analyses ...

future requirements calls for considerable theoretical work, algorithm developments, model compilations and studies of relevant observations ...

SBL service operations ... computing and releasing the loading deformation and relevant geodynamic products, ...

... both vertical and horizontal components on both land surface and ocean bottom, with as high temporal- and spatial-resolution as feasible, and released in a fashion of as near-real time as feasible. ...

... atmosphere, oceans, land hydrology, cryosphere, and tides.

Current Membership

Tonie van Dam	European Center for Geodynamics and Seismology, Luxembourg, (chair)
Hans-Peter Plag	Norwegian Mapping Authority, Norway (co-chair)
Geoffrey Blewitt	University of Nevada, Reno, U.S.A.
Jean-Paul Boy	Goddard Space Flight Center, U.S.A.
Pascal Gegout	Ecole et Observatoire des Sciences de la Terre, Strasbourg, France
Halfdan Pascal Kierulf	Norwegian Mapping Authority, Norway
Tadahiro Sato,	National Astronomical Observatory, Mizusawa, Japan
Hans-Georg Scherneck	Onsala Space Observatory, Sweden
John Wahr	University of Colorado, Boulder, U.S.A.

Members ex-officio: Chairs of the existing SBs

Ben Chao	SB Mantle
Veronique Dehant	SB Core
Richard Gross	SB Oceans
Richard Ray	SB Tides
David Salstein	SB Atmospheres
Michael Watkins	SB Geocenter
Clark Wilson	SB Hydrology

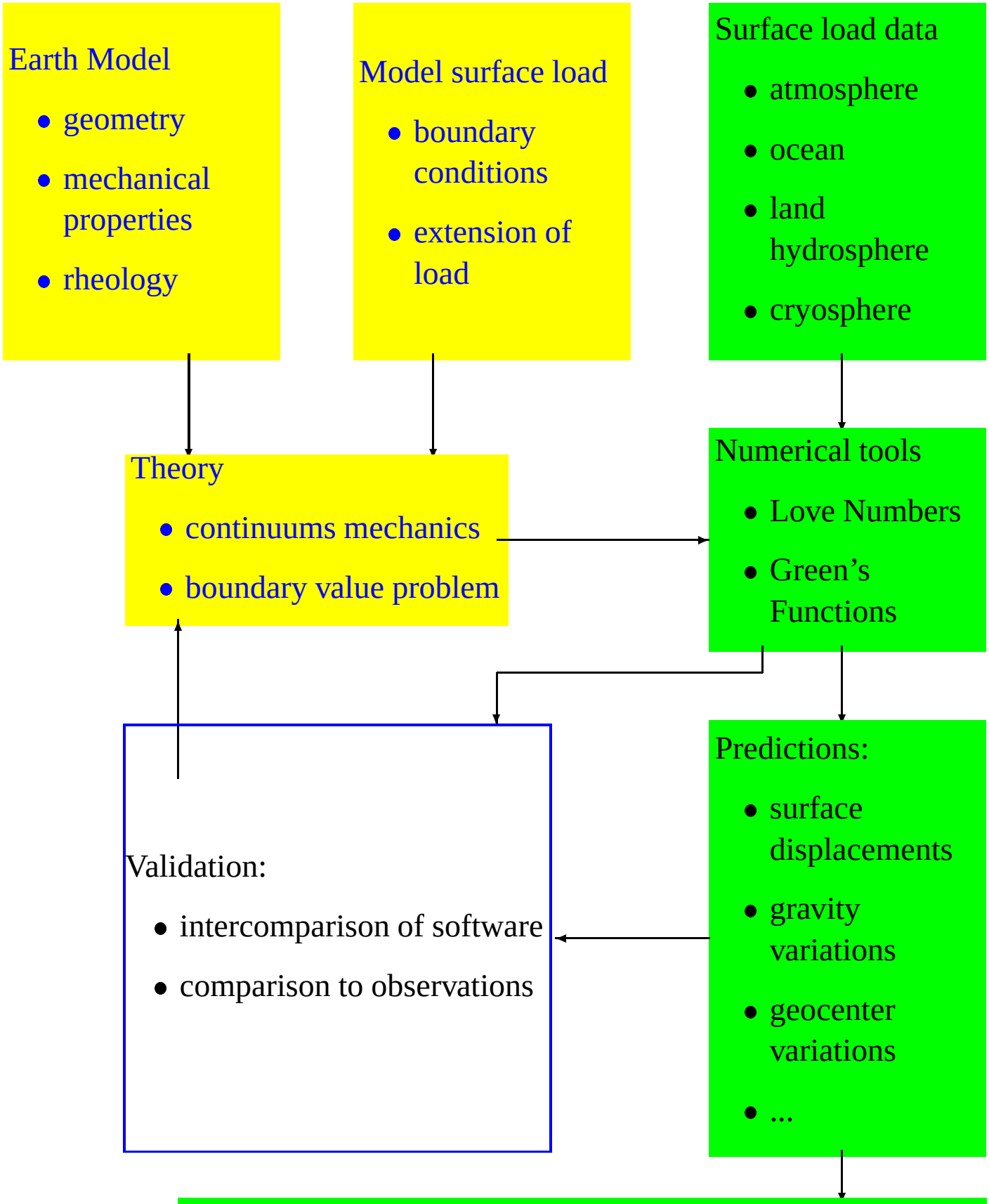
Agenda

Two separate agendas:

operational: provide in near real-time a consistent global solution data set describing at least the surface deformation, gravity signal and geo-centre variations due to the various surface loading process in reference frames relevant for direct comparison with existing geodetic observing techniques.

scientific: major scientific advances with respect to the Earth model, the theory and algorithms used to model deformations of the Earth and the observational data of surface loading.

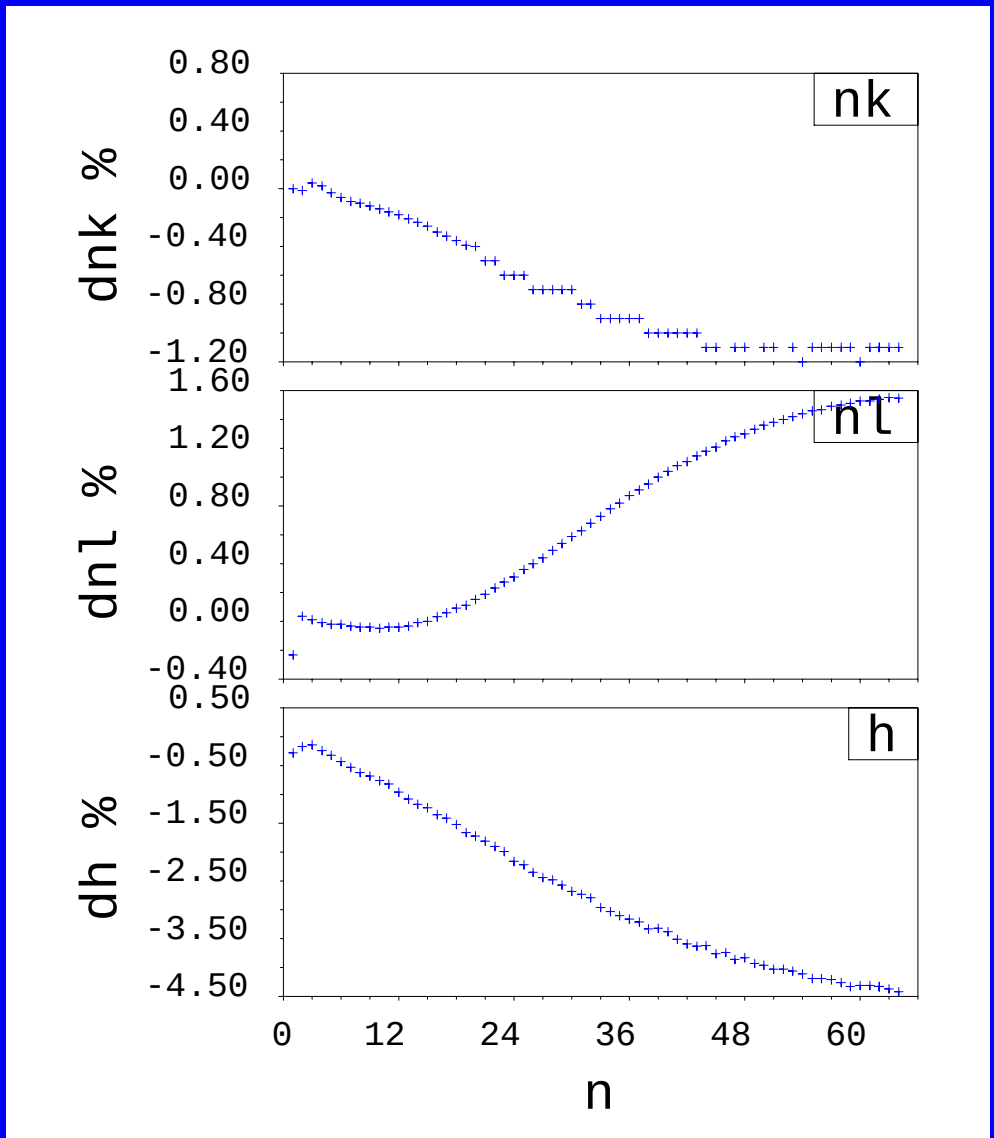
Loading Predictions



Earth Model

Spherically symmetric, non rotating, elastic, isotrop: SNREI

- PREM or ?
- PREM: surface layer: 3 km ocean
- PREM: frequency-dependent shear modulus: elastic module?
- PREM: parameterisation of depth-dependency



Surface Loads

Relevant surface loads:

- atmospheric loading
- ocean loading (tidal and non-tidal)
- continental water storage

Eventually needed:

Gobal pressure field on the surface of the solid Earth:

$p = p(\lambda, \theta, t; h_s)$

where h_s height of Earth's surface.

Density variation above the surface of the solid Earth:

$\delta\rho = \delta\rho(\lambda, \theta, h, t)$

Atmosphere:

- National Center for Environmental predictions, USA (NCEP): Analysies and forecasts for 5 days;
- Japan Meteorological Agency (JMA): Analyses and forecasts to 8 days;
- European Centre for Medium-Range Weather Forcasts (ECMWF): Analysesa nd forecasts to 10 days.

Surface Loads

Ocean (non-tidal):

- two models with regular update:
  - Mercator
  - ECCO
- Forcing: surface wind stress, heat and salinity fluxes

Problems:

- no air pressure forcing;
- spin-up very long;
- mass conservation.

Continental hydrology:

- models using meteorological observations as input:
  - Huang et al. (1996): monthly results 1979 - 1993;
  - Shmakin & Milly (1999): 1978 - 1998, ground water, soil moisture and snow.

Problem: large uncertainties.

General problems:

- reference surface
- trends

Reference Frame

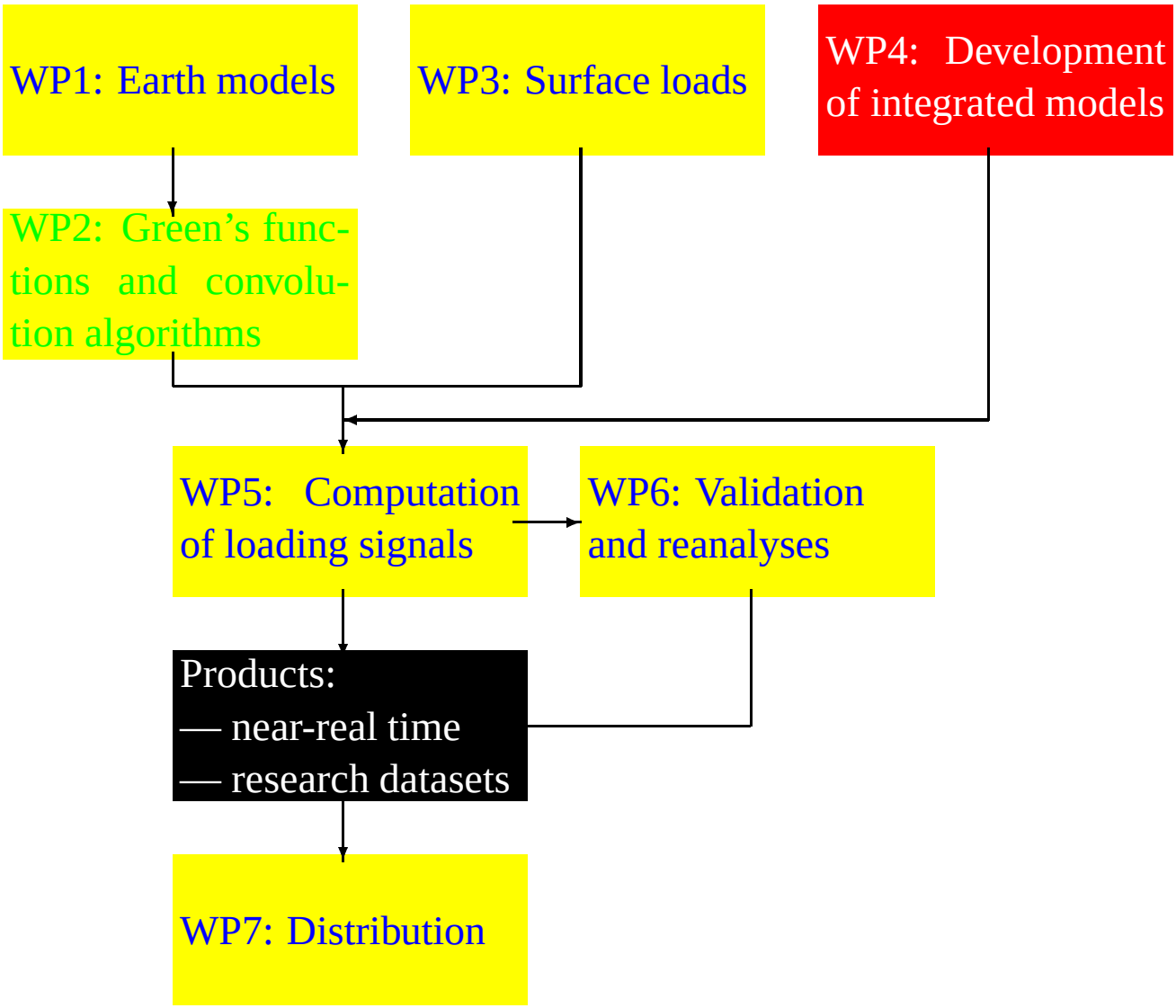
CE: Center of mass of the solid Earth
(Farrell, 1972)

CM: Center of Mass of the Earth System
(SLR)

CM: Center of Figure
(GPS)

Basic difference:
degree-one Load Love Numbers

Loading Predictions



11	**Ocean Bottom Pressure**

Mercator:
Phase 2: January 2002 - second MERCATOR prototype (PSY2). Marks the start of ”high-resolution” MERCATOR forecasting for European seas.
Real-time routine modeling of the North and Mediterranean at high resolution (1/15), assimilating
altimetry and in-situ data and capable of performing analysis and prediction of three-dimensional ocean conditions in these regions.
Real-time routine acquisition of altimetry and in-situ data covering the global ocean, which are then merged to generate a three-dimensional picture.
High-resolution analysis and prediction (1/15) for North Atlantic and Mediterranean Analysis based on global ocean observations

Phase 3: January 2003 - third MERCATOR prototype (PSY3)
Marks the rollout of the MERCATOR system for GODAE.
Real-time routine modeling of the North and Mediterranean at high resolution (1/15), assimilating altimetry and in-situ data.
Real-time routine modeling of the Global Ocean at medium resolution (1/4°), assimilating altimetry and in-situ data and capable of performing analysis and prediction of global three-dimensional ocean conditions.
High-resolution analysis and prediction (1/15°) covering North Atlantic and Mediterranean Analysis and prediction of Global Ocean conditions at medium resolution

Summary of Workshop

Overview Science Plan:

- WP1— Earth Models
  - Decide on the requirements for the Earth model and compute Load Love Numbers.
- WP2 — Green's Functions
  - Determine Green's functions for Earth model of choice;
  - Optimize calculations of loading effects:
    - Compare convolution in space domain ("point loading") with spherical harmonic approach for load functions including ocean effects;
      what order of harmonics is required?
      what happens at the coasts?
      do we need a hybrid approach?
    - Optimize as much as possible point loading computations.
    - Is mass variation with height in the atmosphere significant for gravity observations?

- WP3 — Surface Loads
  - atmospheric surface pressure;
  - ocean bottom pressure;
  - continental water storage;
  - ocean tidal loading;
  - attempt to evaluate the accuracy of available mass loading models.
- WP4 — Integrated Earth system models
  - to be considered in the future

Tentative workplan for 2002:

Feb. 1:	Establishment of the SBL
4-5 March:	Workshop in Luxembourg
March/June:	decide on preliminary Earth model, decide on approach for computing load effects begin to compute historical loading effects set up system for obtaining data in real time
June 1:	Start of NRT demonstration project
July 1:	Workplan for developing more complex loading models
Dec. 1:	Standards for version1 products are available
Jan. 1, 2003:	Global grids of surface deformations and gravity changes due to air pressure loading on SNREI Earth model are available via a web page